

## RESTRAINT SYSTEM

5

FIELD OF THE INVENTION

The present invention relates to a restraint system.

BACKGROUND INFORMATION

- 10 Conventional restraint systems determine the deployment of  
restraining means via the acceleration which is measured on  
the transmission tunnel in the passenger compartment or in the  
exterior area of the vehicle, in the B-pillars for example,  
using peripheral sensors. Two acceleration sensors for each  
15 sensing direction are typically used to avoid erroneous  
deployment. The signals of both sensors are compared with one  
another and the deployment of restraining means, such as  
airbags for example, is permitted only when both sensors  
measure a significant acceleration signal. Such a restraint  
20 system is described in German Patent Application No. DE 197 39  
655. A first acceleration-sensitive sensor is provided in this  
conventional restraint system, a first deployment criterion  
being derived from its output signal. A second deployment  
criterion is derived from the output signal of at least one  
25 additional sensor. At least two complex sensor systems are  
thus required to achieve a highly reliable performance of the  
restraint system and to prevent erroneous deployments in  
particular.
- 30 An accident sensor for triggering a motor vehicle safety  
system is described in German Patent Application No. DE 197 45  
309. This sensor includes deformable plastic parts which are  
mounted on the vehicle, as well as a microphone, in particular  
a structure-borne sound sensor. The deformation of the plastic  
35 parts generates a structure-borne sound that is measured in  
the frequency range of 60 Hz to 100 Hz.

## SUMMARY

In accordance with an example embodiment of the present invention, a substantially simpler and yet reliable restraint  
5 system is provided. In the event of an accident, high-frequency acoustic signals are generated which may be converted into corresponding electrical signals using an electroacoustic transducer and may be analyzed as to whether an accident event is occurring. Particularly advantageous is  
10 the use of an ultrasonic sensor as the electroacoustic transducer, since acoustic signals of high amplitude in the ultrasound range are generated during accident events. An additional deployment criterion for the deployment of restraining means may be derived from these easily analyzable  
15 signals in a relatively simple manner.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is explained in greater detail below  
20 with reference to the exemplary embodiments illustrated in the figures.

Figure 1 shows in a diagram the output signal of an ultrasonic sensor as a function of time in an accident  
25 experiment.

Figure 2 shows a first exemplary embodiment of the present invention in which an ultrasonic sensor is situated in the control unit for sensing the passenger compartment.  
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Figure 3 shows a second exemplary embodiment in which an ultrasonic sensor is situated in the airbag control unit.

Figure 4 shows a third exemplary embodiment in which an  
35 ultrasonic sensor is also situated in the passenger compartment of the vehicle but outside of the airbag control unit.

## DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Figure 1 shows in a diagram the output signal of an  
5 electroacoustic transducer, in particular an ultrasonic  
sensor, as a function of time in an accident experiment.  
During the simulation of a very wide variety of vehicle  
accidents, the output signal of such an ultrasonic sensor US  
shows high amplitude values in a high frequency range of  
10 beyond approximately 50 kHz. In the diagram illustrated in  
Figure 1, the output signal of ultrasonic sensor US is  
detected starting at point in time  $T=T_0$  as part of a crash  
experiment. The vehicle collides with a rigid barrier at a  
velocity of approximately 50 km/h at point in time  $T=T_1$ . As  
15 the diagram shows, the amplitude of the output signal of  
ultrasonic sensor US surges within a very short period of  
time, thereby representing a signal that may be analyzed  
comparatively simply. The generation of such ultrasonic  
signals is attributed to the deformation and breaking of  
20 vehicle parts during an accident.

An ultrasonic sensor US, situated in the passenger compartment  
of a vehicle, detects the ultrasonic signals in the vehicle in  
the event of an accident. In this instance, the ultrasonic  
25 sensor may be situated in the airbag control unit itself, or  
in another control unit, e.g., the control unit provided for  
sensing the passengers. As an external sensor, the ultrasonic  
sensor may alternatively be situated at almost any location  
within the passenger compartment of the vehicle. In the event  
30 that the ultrasonic sensor is installed in the airbag control  
unit itself, the measured signal is analyzed together with the  
signals of acceleration sensors which are also present there.  
In the event that the ultrasonic sensor is situated in a  
different control unit, its output signal is transmitted to  
35 the airbag control unit and analyzed there. A particularly  
advantageous analysis of the output signal of the ultrasonic  
sensor may take place in such a way that the output signal is

initially filtered in a low-pass filter and subsequently compared with a predefinable threshold value. If the threshold value is exceeded, this qualifies as a plausibility decision for the fact that an accident event is occurring. This  
5 plausibility decision is gated with the output signals of additional sensors of the restraint system. If the output signal of the ultrasonic sensor, as well as the output signals of the additional sensors of the restraint system conclude that an accident event is occurring, the deployment of  
10 restraining means such as airbags and seat-belt tensioners is enabled.

In further advantageous embodiments of the present invention, the output signal of the ultrasonic sensor may also be  
15 analyzed by using integration, window integration, bandpass filtering, or a combination of these measures.

A first exemplary embodiment of the present invention is explained with reference to Figure 2, in which ultrasonic  
20 sensor US is situated in control unit AOS for sensing the passenger compartment. Ultrasonic sensor US is connected to a first microprocessor MPI which is situated in control unit AOS. Control unit AOS for sensing the passenger compartment is connected to airbag control unit ACM. A second microprocessor  
25 MP2 and a first acceleration-sensitive sensor IAS of the restraint system are situated in airbag control unit ACM. A second acceleration-sensitive sensor PAS of the restraint system is connected to airbag control unit ACM. First sensor  
30 IAS is a sensor situated inside the vehicle, while second sensor PAS is situated externally. The output of control unit ACM is connected to a restraining means AB, such as an airbag in particular.

The first exemplary embodiment of the present invention  
35 operates as follows. In the event of an accident, acceleration-sensitive sensors IAS and PAS respond and each output a corresponding output signal. In addition, ultrasonic

sensor US, which is situated in control unit AOS for sensing the passengers, detects the high-frequency acoustic oscillations caused by the deformation or breaking of vehicle parts and converts these into a corresponding electrical output signal (Figure 1). High-frequency oscillations starting at approximately 50 kHz are preferably analyzed, since they are particularly characteristic of accident events. The output signal of ultrasonic sensor US is supplied to a low-pass filter (not shown in Figure 2) and analyzed there. The output signal, filtered in this way, is finally supplied to a threshold circuit and compared there with a predefinable threshold value S1. If the filtered output signal exceeds predefinable threshold value S1, it is assessed as a critical signal indicating an accident. If all three sensors, IAS, PAS, and US, deliver critical signals, i.e., signals which indicate an accident, everything suggests that an accident must plausibly be assumed and thus restraining means AB, such as, for example, airbags and/or seat-belt tensioners, must be deployed. This first exemplary embodiment according to Figure 2 is characterized in particular in that it has a very compact and space-saving design, since ultrasonic sensor US is situated in control unit AOS for sensing the passengers. This space-saving configuration makes particularly short electrical connections between ultrasonic sensor US and first microprocessor MP1 possible.

A second exemplary embodiment of the present invention is described in connection with Figure 3. An airbag control unit ACM is illustrated there in the form of a block diagram. This airbag control unit ACM includes a first, internally situated acceleration sensor IAS and a microprocessor MP1. In addition, an external, acceleration-sensitive sensor PAS is connected to control unit ACM. An ultrasonic sensor US is situated directly in control unit ACM. In comparison with the first exemplary embodiment according to Figure 2, this results in an even more compact configuration having particularly short power connections between sensors IAS, US and microprocessor MP1

which is responsible for the analysis of the output signals of these sensors.

A third exemplary embodiment of the present invention is explained with reference to Figure 4. An airbag control unit ACM is again illustrated, which includes an acceleration-sensitive sensor IAS and a microprocessor MP1. An externally situated acceleration sensor PAS is connected to control unit ACM. In addition, an ultrasonic sensor US is provided which is, however, situated outside control unit ACM and connected to it via a line. This exemplary embodiment of the present invention mentioned last is not as compact as the exemplary embodiments of the present invention explained above with reference to Figures 2 and 3. However, a great advantage lies in the fact that in this exemplary embodiment, from the configurational point of view, the ultrasonic sensor may be mounted in an optimal location, independently of control units ACM or AOS. This exemplary embodiment is thus particularly flexible.

It is generally known that an impact on the vehicle body, falling rocks for example, or driving over a pothole, generates acoustic oscillations. However, such oscillations subside again relatively quickly. In order to reliably prevent an erroneous deployment of restraining means in the presence of such innocuous acoustic oscillations, a time threshold is additionally provided in an advantageous further embodiment of the present invention. This means that threshold value S1 must be exceeded at least during a time interval  $\Delta T$  before the ultrasonic signal is considered to be critical.